The Phase-I Trigger Readout Electronics Upgrade of the ATLAS Liquid Argon Calorimeters

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Abstract

A Super Cells design was proposed in the ATLAS LAr Phase-I upgrade to replace the existing trigger system based on a Trigger Tower in order to cope with higher luminosity environments in Run 3 at LHC. The finer granularity of the Super Cell trigger system requires higher data transmission capability and real time digital processing. The new system of the Super Cell is also required to be compatible with the existing trigger system since the Trigger Tower system will remain in Run 3. To fulfill these requirements, the new electronics for the front-end and the back-end have been developed. The demonstrator board for the Super Cell design, installed in 2014, shows good consistency with the main readout in the 2017 collision data.

Keywords: Calorimeters, Liquid Argon, ATLAS Phase-I Upgrade

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1. Introduction

According to the LHC plan, the beam will be delivered at higher luminosity in Run 3. The instantaneous luminosity will be up to $2 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ and the number of interactions goes up to $\langle \mu \rangle = 80$. For existing trigger system using a Trigger Tower in ATLAS [1], low p_T thresholds cannot be retained in such a high luminosity environment. Higher p_T thresholds will cause problems with physics analyses such as the BSM $H \rightarrow ZZ$ [2]. To keep the threshold of single EM trigger as low as possible such as 25 GeV, a new trigger system using Super Cells was proposed [3].¹

A Super Cell has finer granularity than a Trigger Tower. Figure 1 shows the structure of readout cells for both Super Cell and Trigger Tower. In the EM barrels, there are four layers, which are presampler, front, middle and back layers. One Trigger Tower consists of cells of four layers within $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$ and all the signals are summed as the Trigger Tower

Figure 1: Readout cell and layer structure for (a) Trigger Tower and (b) Super Cell in $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$ [3].

signal. There are 10 Super Cell signals from four layers within $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$. The presampler and the back layer remain $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$ but the front and middle layers have finer segmentation in the η direction: $\Delta\eta \times \Delta\phi = 0.025 \times 0.1$. There are about 7200 Trigger Towers and total 34048 Super Cells in the detector. Therefore, the data transmission and processing rate are several times higher than the existing trigger system. New electronics must be developed and adapted for such a high data rate.

2. Electronics

The readout system of LAr Phase-I upgrade is showed in Figure 2. The new electronics are indicated by the red outlines and

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